

COCCONEIS EHRENBERG AND PSAMMOCOCCONEIS GARCIA (BACILLARIOPHYTA) FROM THE GULF OF SAN MATÍAS, PATAGONIA, ARGENTINA

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The morphology and taxonomy of species of the genera *Cocconeis* Ehrenberg and *Psammococconeis* Garcia from the Gulf of San Matías (Patagonia, Argentina) is documented in the present study. A total of 16 taxa of *Cocconeis* and one species of *Psammococconeis* were found in surface net hauls taken in shallow coastal waters of the Gulf. *Cocconeis fluminensis* var. *fluminensis*, *C. fluminensis* var. *subimpleta*, *C. guttata*, *C. peltoides* and *C. neothumensis* var. *marina* are new records for the southwestern Atlantic Ocean.

INTRODUCTION

There are few studies on the diatom flora of the Gulf of San Matías in northern Patagonia, Argentina. In a morphological study of the silicoflagellate *Dictyocha fibula* Ehrenberg, Frenguelli (1935) additionally provided a list of 79 diatom taxa. He later described the diatom flora of the Gulf of San Matías reporting 96 taxa (Frenguelli 1939a). During the 1970s several works dealing with phytoplankton from this area were published (e.g. D'Antoni 1973, Carreto & Verona 1974, Carreto *et al.* 1974, Verona *et al.* 1974). In the last two decades, several studies presented detailed morphological descriptions of diatom taxa from this area as well as information on their seasonal distributions (Sar 1989, 1996a,b, Sar & Ferrario 1990, Sar *et al.* 2002a,b). However, none of these works were devoted to *Cocconeis* Ehrenberg.

Since the mid 1990s, several authors have presented detailed treatments of various *Cocconeis* species, documenting the great morphological variability and taxonomic confusion associated with particular taxa (Witkowski 1993, Riaux-Gobin & Compère 1996, Romero 1996a,b, Romero & Rivera

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1996, Romero & Navarro 1999, De Stefano *et al.* 2000, De Stefano & Marino 2001, Garcia 2001, Suzuki *et al.* 2001a,b). These reports have demonstrated a greater morphological heterogeneity in the ultrastructure of *Cocconeis* frustules than described in Round *et al.* (1990). Based on this ultrastructural variability, Garcia (2001) recently separated *C. discoloides* Hustedt from *Cocconeis* and transferred it to her new genus, *Psammococconeis*. Despite these recently published works, many uncertainties about the characterization and identification of many species of *Cocconeis* still remain. VanLandingham (1968) included ca. 320 taxa in *Cocconeis*; however, only about 100 of them have been fully characterised (i.e. both valves described) and recorded at least once by someone other than the original author. Many species, varieties or forms are known only from their very brief original descriptions and rather poor illustrations, and for most of them no information on the fine structure of their valves has been published (see Gaul *et al.* 1993).

In a study of the suitability of different diatom species as a food source for oysters in a hatchery located in the Gulf of San Matías (Patagonia, Argentina), we encountered a number of *Cocconeis* and *Psammococconeis* species. The purpose of the present paper is to document the species of *Cocconeis* and *Psammococconeis* occurring in the Gulf of San Matías, by providing descriptions based on light and scanning electron microscopy. Remarks on their distribution, taxonomic problems and comparisons with similar species are also given.

MATERIAL AND METHODS

The study area was located in the northern part of the Gulf of San Matías, Patagonia, Argentina. Monthly sampling was carried out from April 1998 to February 2000 at eight inshore stations (Fig. 1). This zone is characterised by a strong resuspension of bottom material caused by tidal currents in the shallow waters of the San Antonio Bay and neighbouring coastal environments, which explains the frequent occurrence of benthic diatom cells in the phytoplankton. Specimens analysed in the present paper were found in qualitative plankton samples collected in the framework of a research project focused on planktonic diatoms. Samples were taken between 0 and 5 meters with a 30 µm mesh net and fixed immediately with 4% formalin. Preserved samples were rinsed with distilled water to remove salt and preservatives, and the organic matter was then oxidized following Hasle & Fryxell (1970). The cleaned material was prepared for examination in light and scanning microscopy according to Ferrario *et al.* (1995). Preserved and cleaned material and microscopic slides are deposited in the Colección de Diatomeas Argentinas, Departamento Científico Ficología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata (LPC 4550 to LPC 4643).

Type material of *Cocconeis discoloides* (slides Zt1/79, lectotype and Zt1/92, isolectotype) and the cleaned material used by Hustedt for the preparation of the types (sample Am 792) were obtained from the Hustedt Diatom Collection deposited at the Alfred Wegener Institut für Polar und Meeresforschung in Bremenhaven, Germany.

Diatom material was examined in light microscopy under phase contrast (LM) using a Wild M20 and a Nikon Microphot-FX, and in scanning electron microscopy (SEM) using a Jeol JSMT 100 and an ISI-DS 130.

Terminology follows Anonymous (1975), Ross *et al.* (1979), Holmes *et al.* (1982) and Round *et al.* (1990). According to Romero (1996a) we use the terms sternum valve (SV) and raphe-sternum valve (RSV) for the araphid and raphid valves, respectively. Striae were always counted along the valve margin at the valve centre.

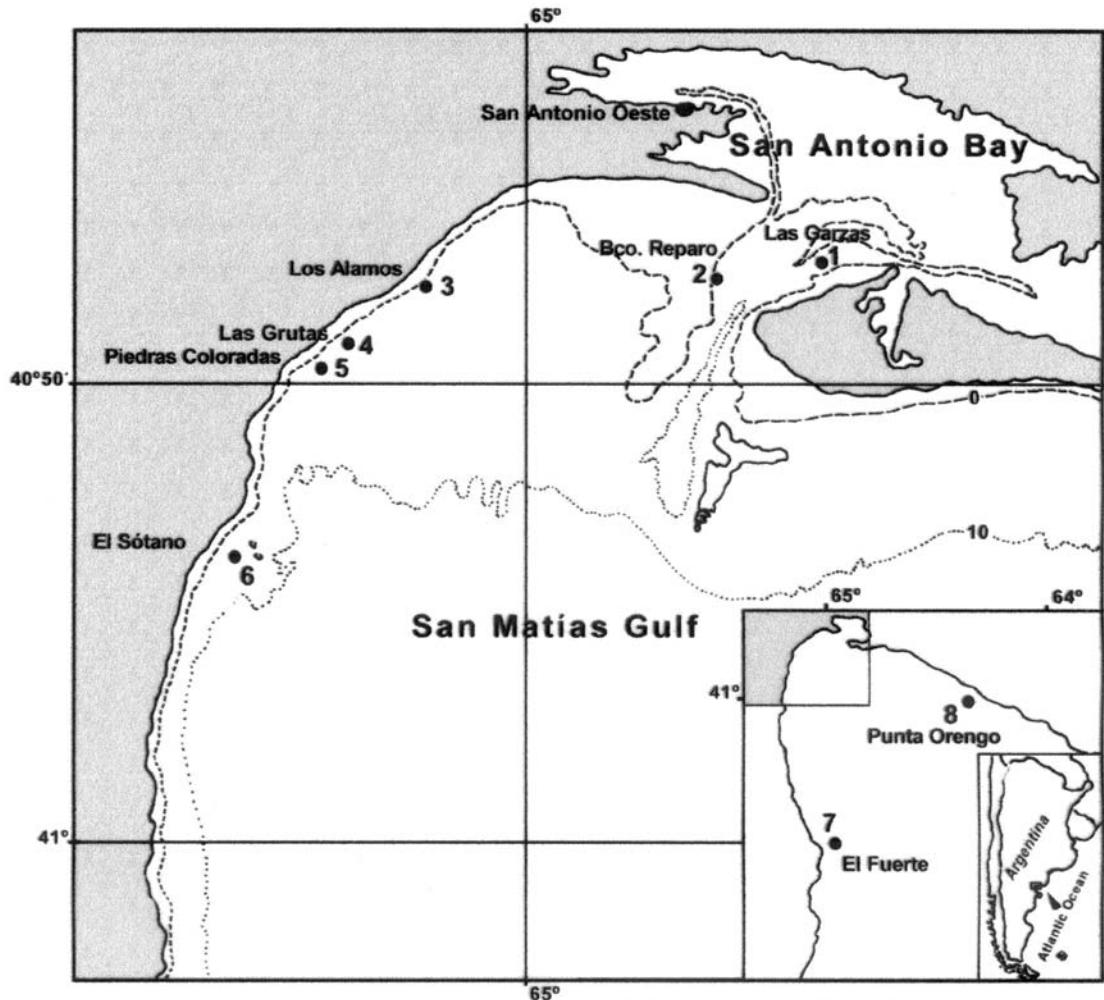


Fig. 1. Location of sampling sites in the northern part of the Gulf of San Matías, Patagonia, Argentina.

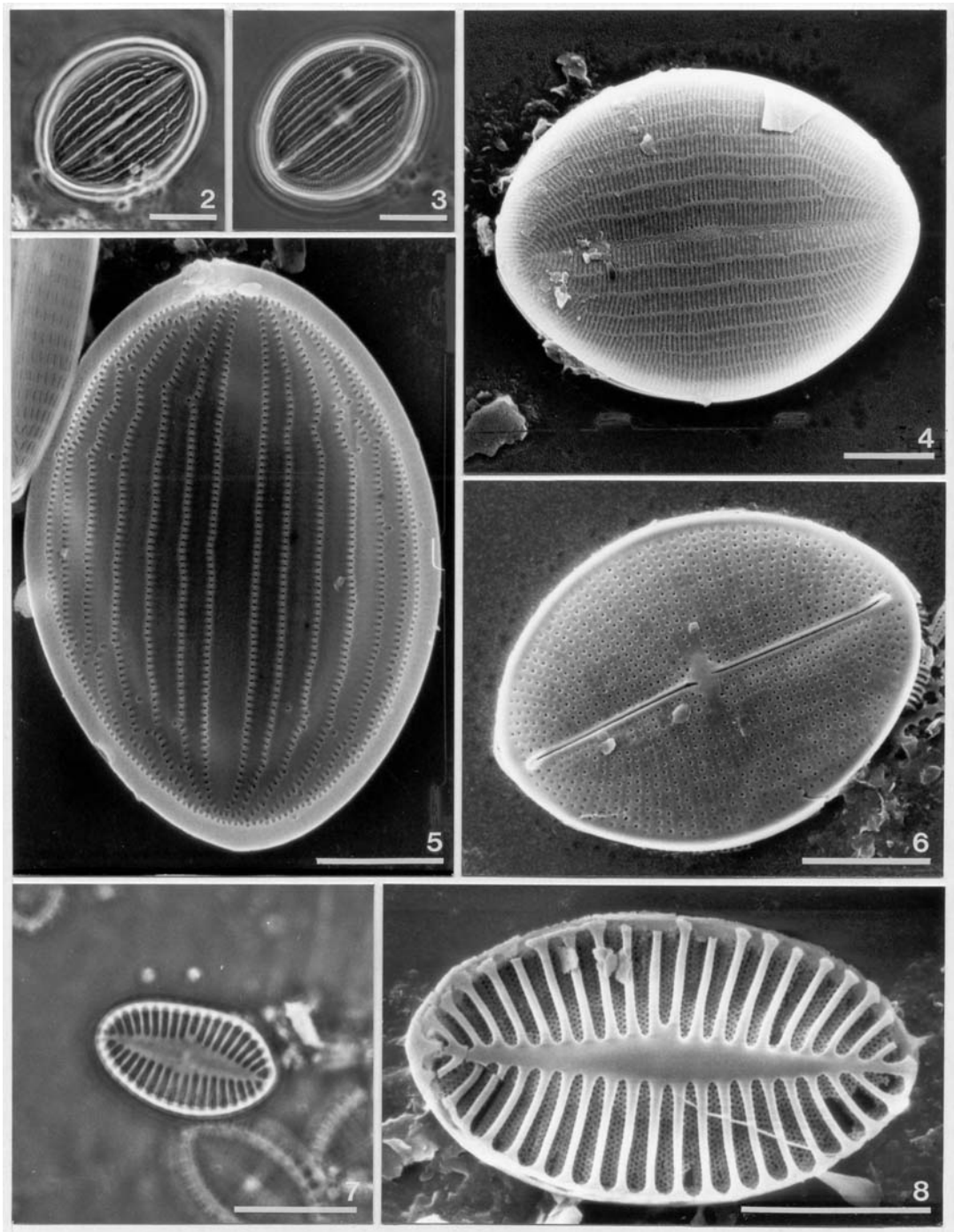
OBSERVATIONS

Cocconeis convexa Giffen (Figs 2–6)

Giffen 1967, p. 257, pl. 2, figs 26–28; Navarro 1982a, p. 322, figs 10–13; Suzuki *et al.* 2001a, p. 60, figs 1–35.

Morphometric data: length 13.5–40 μm , width 9.6–27 μm , striae in 10 μm , SV 34–40, RSV 20–22, areolae in 10 μm , SV 7–10, RSV 28–30.

There are differences in striae density of the SV in the literature. Giffen (1967) and Sar (1996b) reported the lowest, 28–30 in 10 μm , while Navarro (1982a,b) the highest, 46–47 in 10 μm , measured along the margin near the valve centre. Despite these differences, the overall morphology is quite similar in all specimens examined.



Figs 2–6. *Cocconeis convexa*. Figs 2, 3. LM. Figs 4–6. SEM. **Figs 2, 3.** SV and RSV, respectively. **Fig. 4.** External view of SV. **Fig. 5.** Inside view of SV. **Fig. 6.** Internal view of RSV. **Figs 7, 8.** *Cocconeis cf. costata* var. *pacifica*. **Fig. 7.** LM. **Fig. 8.** SEM. **Fig. 7.** SV. **Fig. 8.** SV showing internal axial plate. Scale bars = 10 μm (Figs 2, 3, 7) or 5 μm (Figs 4–6, 8).

In their comprehensive description of *Cocconeis convexa*, Suzuki *et al.* (2001a) pointed out that the proximal raphe ends are internally undilated and slightly deflected, with their curvature being in an opposite direction to that of the helictoglossae. However, in our material (Fig. 6) as well as in figs 12–14 of Suzuki *et al.* (2001a) both ends of each raphe branch are curved in the same direction, opposite to those of the other branch. Some specimens from San Matías Gulf (Fig. 5) show the foramina of the alveola arranged in longitudinal rows slightly oblique with respect to the axial area.

In LM, *Cocconeis convexa* resembles *C. pediculus* Ehrenberg and *C. placentula* var. *euglypta* (Ehrenberg) Cleve, but they all differ in their fine structure (see Gerloff & Rivera 1979, Poulin *et al.* 1984).

Distribution: *Cocconeis convexa* was originally described from South Africa by Giffen (1967), but has been reported as a pantropical species by Navarro (1982a). It was also reported in temperate coastal waters by Sar (1996b) from Argentina and by Suzuki *et al.* (2001a) from Japan.

***Cocconeis* cf. *costata* var. *pacifica* (Grunow) Grunow (Figs 7, 8)**

Grunow in Van Heurck 1880–1885, pl. 30, figs 13,14; Romero & Rivera 1996, p. 330, figs 35–53, table 2.

Valves elliptical, 8–13.5 µm long, 4.8–7.8 µm wide. SV convex with a linear sternum gradually broadening towards the valve centre. Sternum projecting internally to form a lanceolate axial plate of variable width. Striae, 11–13 in 10 µm, composed of three to five rows of circular areolae (65–70 in 10 µm) in quincunx, gradually widening towards the margin. Interstriae strongly silicified internally.

Our taxon is very similar to *Cocconeis costata* var. *pacifica*, previously studied by Romero & Rivera (1996). The main difference is in the density of striae and areolae, which is higher in the specimens from the Gulf of San Matías than in populations from the southeast Pacific Ocean. Specimens collected by Romero & Rivera (1996) possessed 4–6 striae and 20–25 areolae in 10 µm. We have not found any other variety of *C. costata* with the density of striae and areolae characterising our material. Since the axial plate of the SV is a structure apparently only present in the var. *pacifica* among varieties of *C. costata*, we consider our material to be most related to this variety. Moreover, only a few specimens have been found and we lack observations of the RSV.

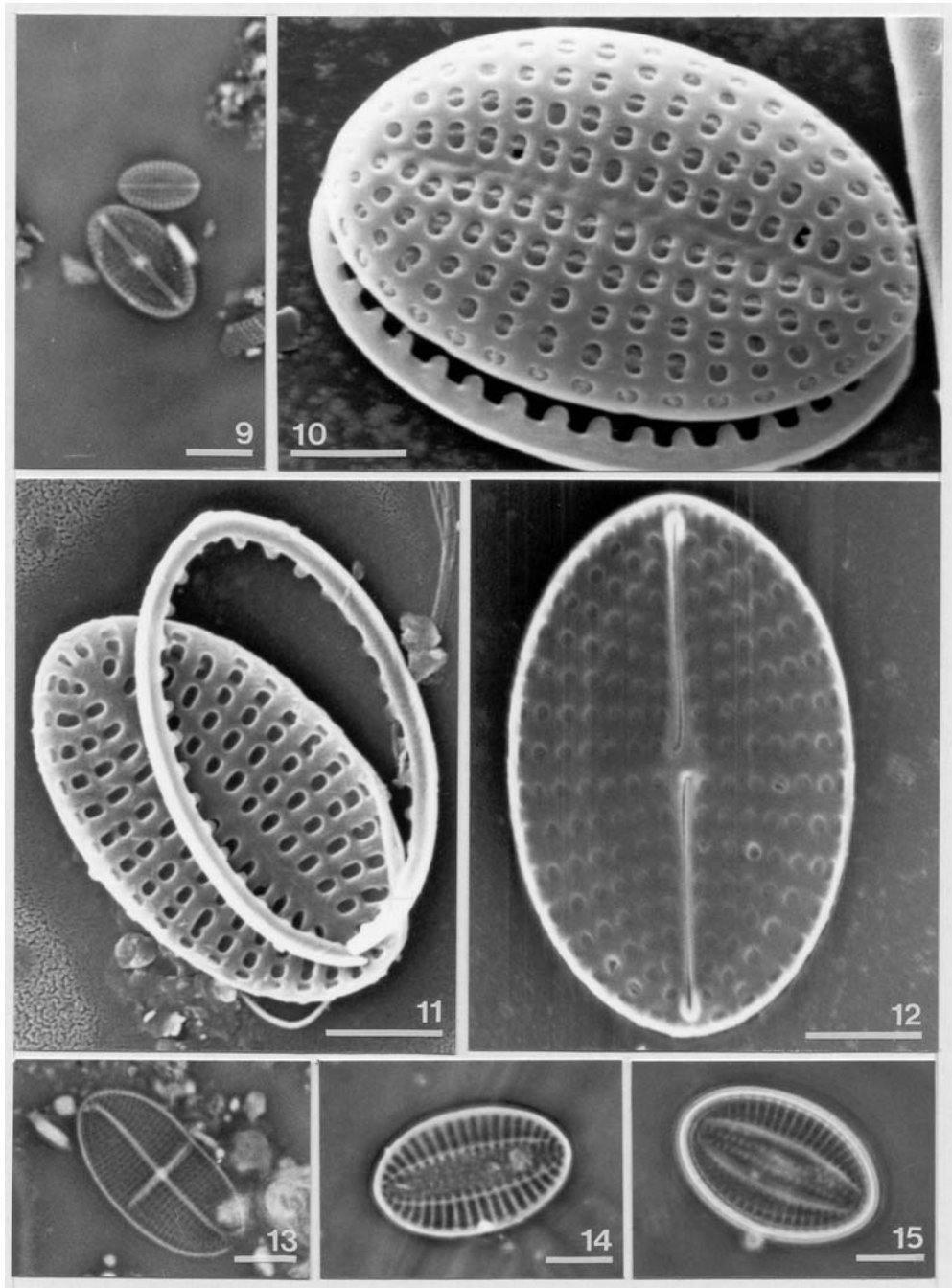
Distribution: We have only encountered this taxon in Banco Reparo and Bajo de Oliveira (Fig. 1).

***Cocconeis* sp. (Figs 9–12)**

Montgomery & Miller 1978, pl. 67, fig. A as *C. diminuta* Pantocsek.

Both valves morphologically similar, small and elliptical, 6.4–10.2 µm long, 4–6.5 µm wide. SV slightly convex, with linear sternum, externally depressed. Central area undifferentiated. Striae uniseriate, mostly radiate and slightly curved towards the apices, 12–16 (18) in 10 µm. Areolae with subrectangular openings both internally and externally, 14–16 in 10 µm. A row of elliptical and smaller areolae on the valve margin. Areolae externally occluded by rota. Valve mantle smooth and shallow. Valvocopula narrow and open at one apex with peg-like fimbriae, all of the same length. RSV flat to concave. Raphe branches straight with proximal fissures internally curved in opposite directions, distal ends terminating in helictoglossae. Sternum linear and narrow. Striae uniseriate, parallel at the centre, becoming radiate and curved towards the apices, 14 in 10 µm. Areolae mostly circular on valve surface, 24 in 10 µm, and elliptic and larger at the margin.

The overall morphology and morphometric data of our taxon coincide with the original description of *Cocconeis diminuta* Pantocsek (1902), except for a narrow sternum. Montgomery & Miller (1978) assigned to *C. diminuta* specimens from Florida Keys that are conspecific with ours.



Figs 9–12. *Cocconeis* sp. **Fig. 9.** LM. **Figs 10–12.** SEM. **Fig. 9.** Small SV and larger RSV. **Fig. 10.** External view of SV showing the peg-like fimbriae of valvocopula. **Fig. 11.** Internal view of SV. Note valvocopula is open at one end. **Fig. 12.** Internal view of RSV. **Fig. 13.** *Cocconeis disruptoides*, LM. RSV showing sigmoid raphe sternum and narrow stauros-like area. **Fig. 14.** *Cocconeis fluminensis* var. *fluminensis*, LM. SV. **Fig. 15.** *Cocconeis fluminensis* var. *subimpleta*, LM. SV. Note rows of areolae parallel to sternum. Scale bars = 5 μ m (Figs 9, 13–15) or 2 μ m (Figs 10–12).

However, Krammer (1990) pointed out that the protologue of Pantocsek's species is incomplete and erroneous, the illustrations do not coincide with the description, and the type material is lost. Considering that the name has been widely used in a sense that conflicts with the protologue we conclude that it should not be applied to our taxon. Finally, we have chosen not to describe *Cocconeis* sp. as a new species in the present study because of a paucity of specimens available for analysis.

Distribution: This taxon was reported by Montgomery & Miller (1978) as *Cocconeis diminuta* from the Florida Keys. We encountered it in Punta Orenge, Banco Reparó, Las Grutas, Piedras Coloradas, Bajo de Oliveira and El Fuerte (Fig. 1). Romero (unpublished observations) also found it in Chilean coastal waters.

***Cocconeis diruptoides* Hustedt (Fig. 13)**

Hustedt 1933, p. 356, fig. 810; Frenguelli 1938, p. 272, pl. 1, fig. 18; Simonsen 1987, p. 133, pl. 219, figs 5–14; De Stefano & Marino 2001, p. 299, figs 15–27, 48, 49.

Valves elliptical, 18 µm long, 9 µm wide. SV with narrow, linear-sigmoid sternum reaching valve ends. Striae uniseriate, 22 in 10 µm, almost parallel at the valve centre, radiate and slightly curved towards the apices. Areolae transapically elongated, 16–18 in 10 µm. RSV with a narrow, sigmoid raphe sternum which is accompanied by a stauros-like area that does not reach valve margins.

Simonsen (1987) designated slide 58/77 (Grotte auf Ranuik b. Lissa) as the lectotype of *Cocconeis diruptoides*. From Simonsen's illustrations, it is possible to obtain morphometric data (length: 15–20 µm; width: 6.5–10 µm; striae in 10 µm, SV: 24–28, RSV: 21–24) which amplify those given in the protologue by Hustedt (1933).

Two taxa morphologically similar to *Cocconeis diruptoides* are *C. dirupta* Gregory and *C. dirupta* var. *flexella* (Janisch & Rabenhorst) Grunow. Based on Hustedt's (1933) illustrations, *C. diruptoides* differs from *C. dirupta* var. *flexella* mainly by the shape of the SV sternum which is narrower in the former. The valve outline is the most important difference between *C. dirupta* and *C. diruptoides*, broadly elliptical to orbicular in the former and elliptical in the latter. The striae density is similar in both species, 18–27 in both valves of *C. dirupta*, and 24–28 in SV, 21–30 in RSV of *C. diruptoides*. Our specimens closely resemble those illustrated by Simonsen (1987), but mainly differ in the striae density of the SV (22 versus 24–28 in 10 µm). Nevertheless, we believe they are conspecific with the species described by Hustedt (1933). Recently, De Stefano & Marino (2001) erected a new species, *C. pseudonotata*, which closely resembles *C. diruptoides* in gross morphology, but is more closely related to *C. notata* based on the morphology of the valves and valvocopulae.

Distribution: According to De Stefano & Marino (2001) *Cocconeis diruptoides* has a wide distribution in temperate and warm seas. This species has been reported from San Blas Bay (Frenguelli 1938), Gulf of San Matías (Frenguelli 1939a) and Rada Tilly (Frenguelli 1939b), all Patagonian localities.

***Cocconeis fluminensis* (Grunow) Peragallo & Peragallo var. *fluminensis* (Fig. 14)**

Peragallo & Peragallo 1897–1908, p. 17, pl. 3, figs 10–12; Hustedt 1933, p. 341, fig. 794.

Valves elliptical, 15.6–22.4 µm long, 9.6–14.4 µm wide. SV with an elliptical-lanceolate central area laterally limited by costae and an inconspicuous, very narrow linear sternum. Granules usually evident within central area. Striae uniseriate, radiate at valve centre and curved towards apices, 8–11 in 10 µm. Areolae round, 14–17 in 10 µm.

Our specimens are smaller and possess a higher stria density than those described by Peragallo & Peragallo (1897–1908) and Hustedt (1933) (15.6–22.4 µm long, 9.6–14.4 µm wide versus 25–60 µm

long, 18–40 μm wide; 8–11 versus 7–9 striae in 10 μm). *Cocconeis fluminensis* morphologically resembles *C. peltoidea* and *C. pelta* (see discussion below).

Distribution: *Cocconeis fluminensis* var. *fluminensis* has been found along southern European coasts (Peragallo & Peragallo 1897–1908, Hustedt 1933), and in the Gulf of California (Moreno *et al.* 1996). It is reported here for the first time from the marine coasts of the southwestern Atlantic Ocean.

***Cocconeis fluminensis* var. *subimpleta* Peragallo & Peragallo (Fig. 15)**

Peragallo & Peragallo 1897–1908, p. 18, pl. 3, fig. 13.

Valves elliptical, 14–16.5 μm long, 10–11 μm wide. SV with an elliptical-lanceolate central area laterally limited by costae. There is one row of areolae on each side of the sternum. The rest of the valve surface is visibly striated. Striae uniseriate, radiate at valve centre and curved towards valve ends, 11–13 in 10 μm .

Cocconeis fluminensis var. *subimpleta* closely resembles the nominate variety, except for the rows of areolae parallel to the sternum of the SV.

Distribution: *Cocconeis fluminensis* var. *subimpleta* has been recorded only from Barcelona by Peragallo & Peragallo (1897–1908). It is reported here for the first time from the marine coasts of the southwestern Atlantic Ocean.

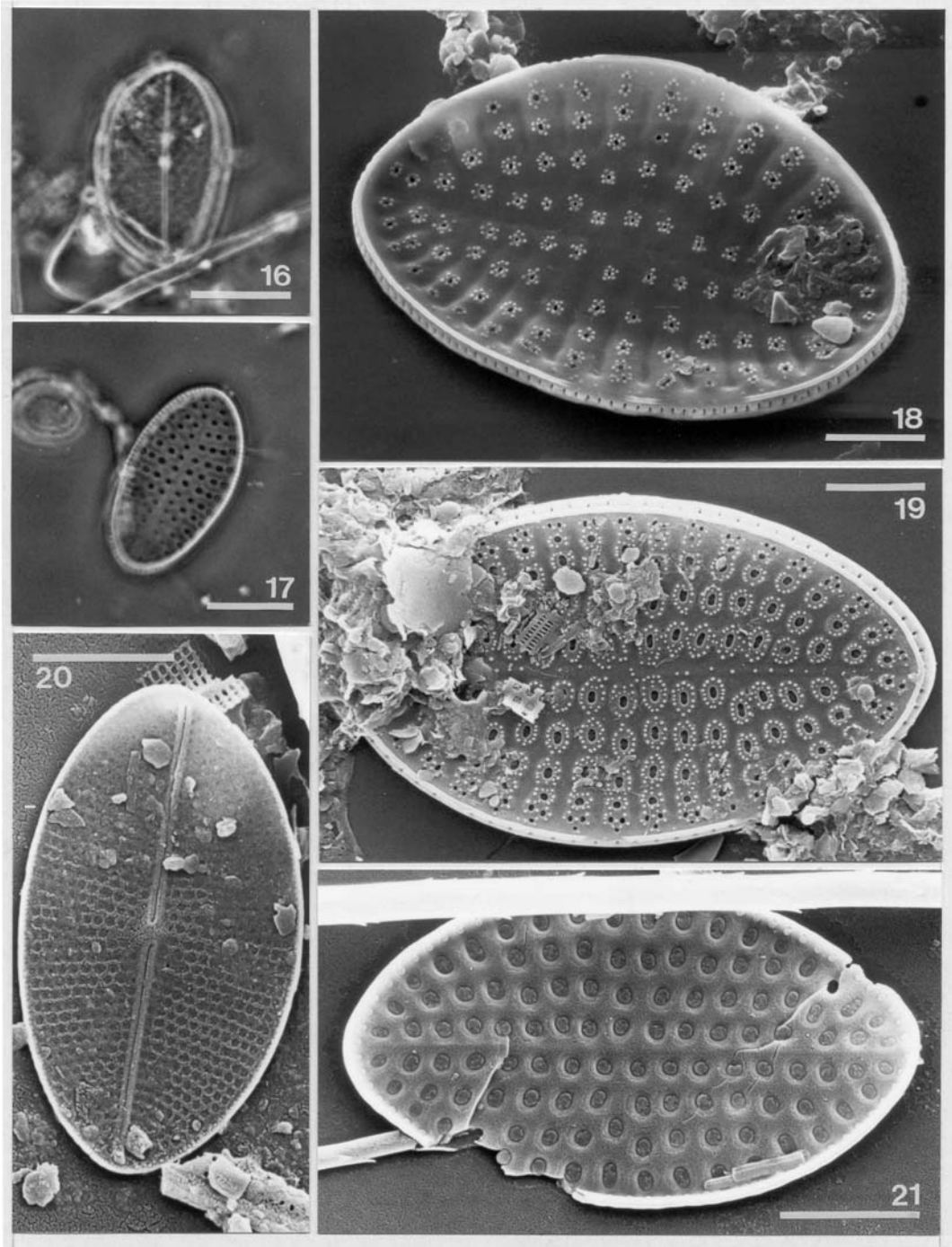
***Cocconeis guttata* Hustedt & Aleem (Figs 16–21)**

Hustedt & Aleem 1951, p. 182, figs 1e,f; Simonsen 1987, p. 367, pl. 552, figs 1–5; Riaux-Gobin 1991, p. 128, pl. 3, fig. 2.

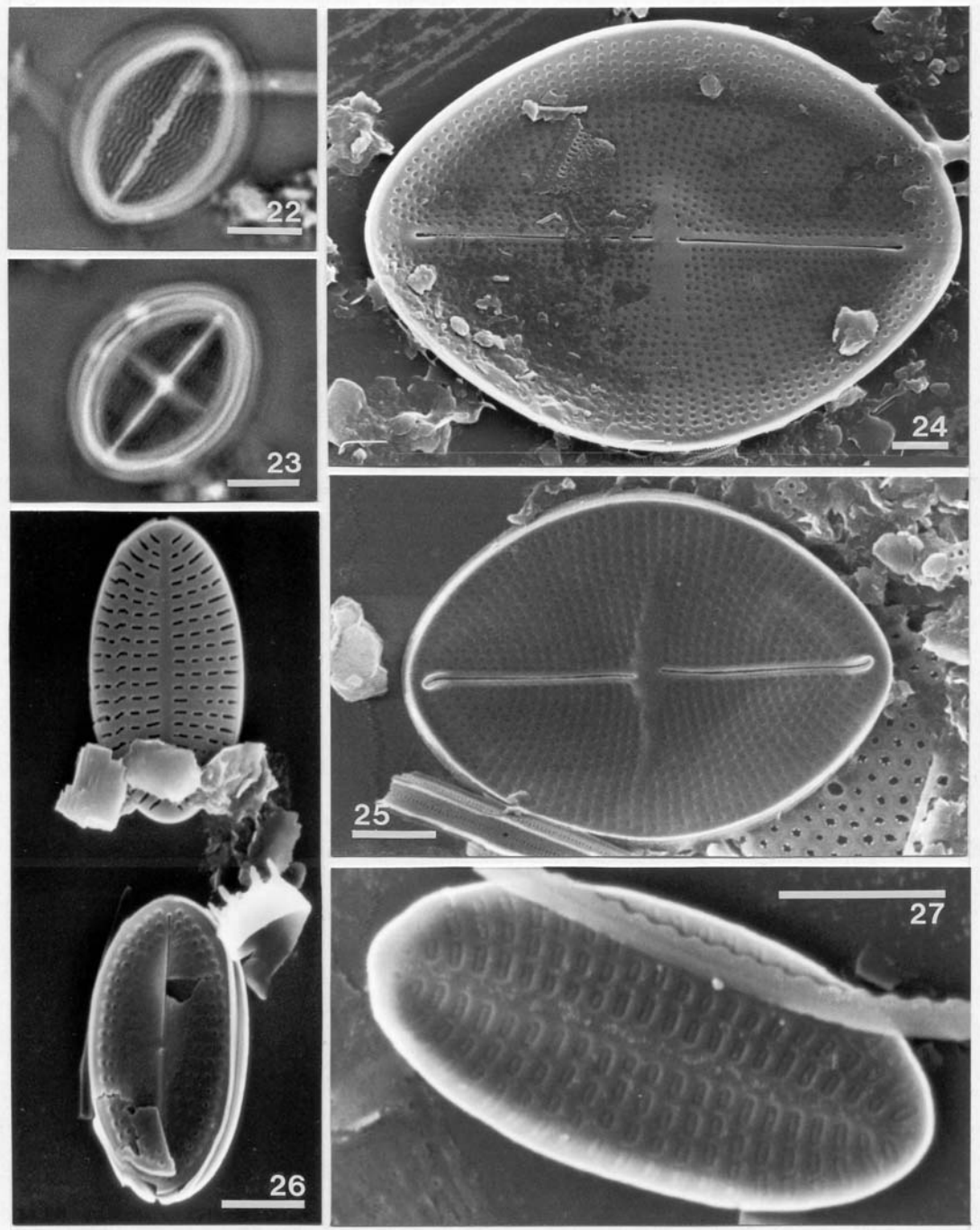
Valves elliptical to lanceolate, somewhat asymmetrical to both apical and transapical axes, 20–31 μm long, 10–18 μm wide. SV concave with linear sternum (slightly lanceolate in some specimens). Central area lacking. Striae uniseriate and radiate, (4) 7–9 in 10 μm , terminating as two or three small areolae in some specimens. Areolae round to subquadrangular, 5–8 in 10 μm , externally surrounded by irregularly arranged small granules, internally occluded. Transapical and longitudinal interstriae somewhat depressed. Distinct marginal ridge separates valve face from mantle. Mantle vertical, possessing a simple row of slit-like areolae, 12–18 in 10 μm . RSV with a linear raphe-sternum, internally thickened, with a small rounded central area. Striae uniseriate, radiate to curved towards the apices, 20–23 in 10 μm . Areolae rounded, 25 in 10 μm .

Hustedt & Aleem (1951) pointed out that *Cocconeis guttata* resembles *C. distans* Gregory in shape and structure of the valves and they differ mainly in striae density, which is higher in the former (SV: 8–9 versus 4–5 striae in 10 μm ; RSV: 22 versus 12–14 striae in 10 μm). Our material agrees in general appearance and morphometric data with Hustedt's protologue and with illustrations of the holotype provided by Simonsen (1987), but we found some specimens (Figs 18, 19) with a lower number of striae in the SV (4–5 in 10 μm).

Distribution: *Cocconeis guttata* has been recorded from coastal waters of England (Hustedt & Aleem 1951, Hendeby 1964) and France (Riaux-Gobin 1991). It is reported here for the first time from marine coasts of the southwestern Atlantic Ocean.



Figs 16–21. *Cocconeis guttata*. Figs 16, 17. LM. Figs 18–21. SEM. Scale bars = 10 μm (Figs 16, 17) or 5 μm (Figs 18–21). **Fig. 16.** Complete frustule. **Fig. 17.** SV. **Fig. 18.** External view of SV. Note depressed interstriae, elevated striae and small siliceous granules surrounding areolae. **Fig. 19.** External view of SV. Note striae terminating as two or three small areolae. **Fig. 20.** Internal view of RSV. **Fig. 21.** Internal view of SV.



Figs 22–25. *Cocconeis molesta* var. *crucifera*. Figs 22, 23. LM. Figs 24, 25. SEM. **Figs 22, 23.** Different foci showing SV and RSV of same frustule. **Fig. 24.** External view of RSV. **Fig. 25.** Internal view of RSV. Note stauros do not reach valve margin. **Figs 26, 27.** *Cocconeis neothumensis* var. *marina*, SEM. **Fig. 26.** Internal view of SV (top) and external view of RSV (bottom). **Fig. 27.** Internal view of SV. Note areolae occluded by hymenes. Scale bars = 5 μ m (Figs 22, 23) or 2 μ m (Figs 24–27).

***Cocconeis molesta* var. *crucifera* Grunow (Figs 22–25)**

Grunow in Van Heurck 1880–1885, pl. 30, figs 20–23; Hustedt 1933, p. 352, fig. 805 c–d; Kobayasi & Nagumo 1985, p. 97, pl. 1, figs 1–15; De Stefano *et al.* 2000, p. 230, figs 33–36.

Morphometric data: length 12–21 μm , width 8.5–16 μm , striae in 10 μm , RSV 20–30, areolae in 10 μm , SV 20–24, RSV 30–35.

Grunow in Van Heurck (1880–1885) erected *Cocconeis molesta* var. *crucifera* without supplying a description. However, he provided illustrations for its identification; therefore, this taxon's name is validly published according to the Article 44 of the ICBN (Greuter *et al.* 2000). Grunow's illustrations show that the SV has wavy longitudinal striae, and the RSV bears a narrow raphe-sternum, with distal raphe endings that deflect in opposite directions and terminate short of the valve apices. A conspicuous stauros is also present. These morphological features and the morphometric data obtained from Grunow's illustrations agree with those provided by Hustedt (1933).

Specimens of *Cocconeis molesta* var. *crucifera* studied in electron microscopy by Kobayasi & Nagumo (1985) and De Stefano *et al.* (2000) mostly agree with descriptions given by Grunow in Van Heurck (1880–1885) and Hustedt (1933). The only difference is the higher striae density of the SV (30 in 10 μm in Grunow in Van Heurck and Hustedt, versus 38 in 10 μm in Kobayasi & Nagumo and 35–37 in 10 μm De Stefano *et al.*). Our specimens possess a lower striae density in the RSV (20–30 in 10 μm), but otherwise agree with descriptions of previously cited authors. Hence, we propose that the range for striae density in this species should be enlarged.

Cocconeis molesta var. *crucifera* resembles *C. dirupta* var. *dirupta* in general appearance. However, the former has a straight raphe sternum with distal ends deflected in opposite directions and terminating short of the valve apices, while the latter has a sigmoid raphe sternum terminating close to the valve apices. Besides, both taxa differ in the morphology of the areolae of the SV, as well as in the structure of the hymenes (see Kobayasi & Nagumo 1985).

Distribution: *Cocconeis molesta* var. *crucifera* has been reported from coastal waters in England and France (Cleve 1895, Peragallo & Peragallo 1897–1908), Japan (Kobayasi & Nagumo 1985), the Baltic Sea (Snoeijs & Balashova 1998) and the Mediterranean (Hustedt 1933, De Stefano *et al.* 2000). Frenguelli (1930) reported this species from Buenos Aires coastal waters.

***Cocconeis neothumensis* var. *marina* De Stefano, Marino & Mazella (Figs 26–31)**

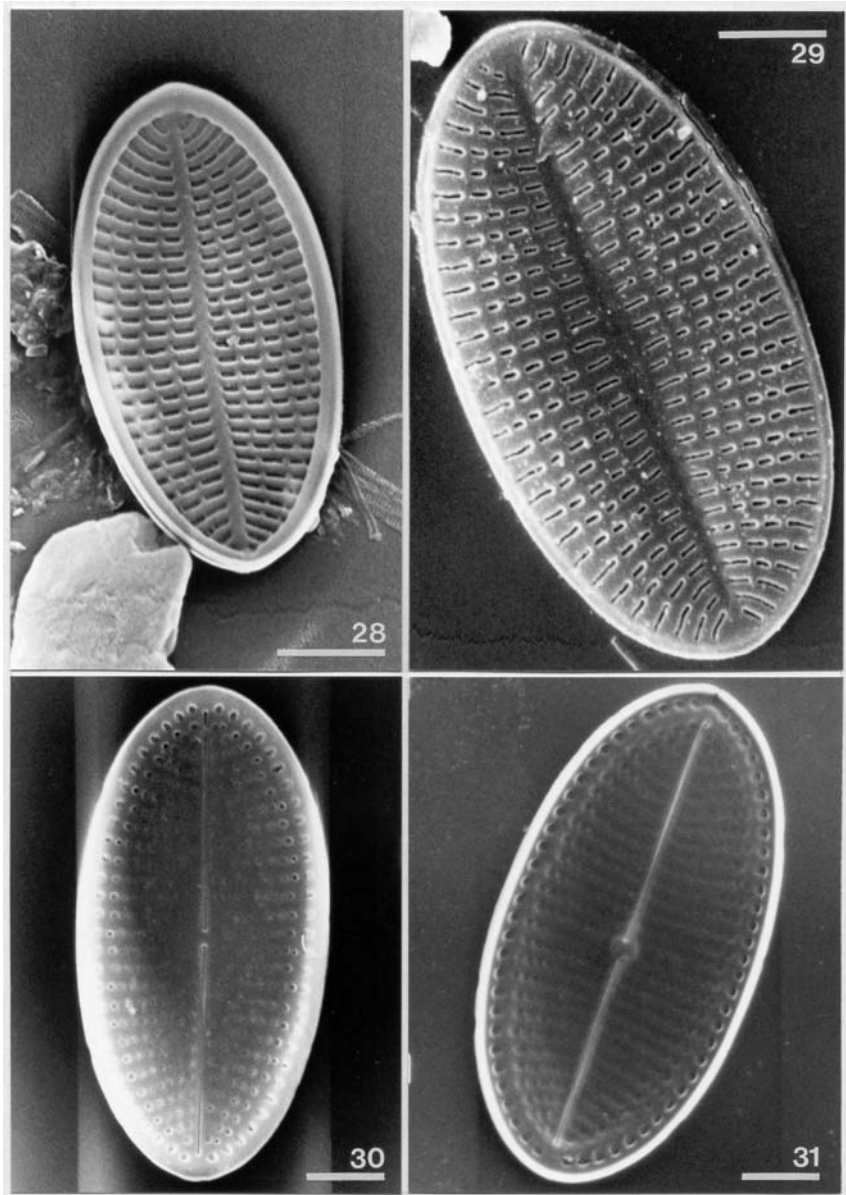
De Stefano *et al.* 2000, p. 233, figs 53–65.

Morphometric data: length 6–13 μm , width 3.4–8.5 μm , striae in 10 μm , SV 21–28, RSV 20–30, areolae in 10 μm , SV 25–30, RSV 28–40.

Our specimens closely resemble the recently described taxon from the Gulf of Naples (De Stefano *et al.* 2000). However, in some of the Argentinian specimens the striae density is lower and a narrow, hyaline submarginal area is present on the RSV. Although De Stefano *et al.* (2000) described the areolae as having external occlusions on both valves, it is difficult to establish the position of the hymenes from their illustrations (De Stefano *et al.* 2000, figs 54, 56, 59, 61). Some specimens collected in the Gulf of San Matías have internally occluded areolae (Figs 27, 31) whereas others have lost their hymenes during the cleaning treatment (Fig. 28). *Cocconeis neothumensis* var. *marina* closely resembles *C. placentula* var. *euglypta* in general appearance. Nevertheless, besides the differences pointed out by De Stefano *et al.* (2000), we observed that in the former an internal view of the SV (Figs 27, 28) reveals slit-like to subrectangular areola openings, while in the latter ovoid foramina are arranged in longitudinal rows as in *C. convexa* (see Montgomery & Miller 1978, pl. 67, fig. F). Moreover, the valvocopulae of both valves are regularly crenulated in *C. neothumensis* var. *marina* (Figs 27, 28; De Stefano *et al.* 2000, figs 61, 64), and irregularly fimbriated in *C. placentula* var.

euglypta, a feature apparently common in all members of the *placentula* group (see Krammer & Lange-Bertalot 1991, plates 49, 50, 53).

Distribution: *Cocconeis neothumensis* var. *marina* was recently described from the Gulf of Naples, Italy, by De Stefano *et al.* (2000). It is reported here for the first time in marine coastal waters of the southwestern Atlantic Ocean.



Figs 28–31. *Cocconeis neothumensis* var. *marina*, SEM. All scale bars = 2 µm. **Fig. 28.** Internal view of SV. Note open valvocopula with crenulate fimbriae. **Fig. 29.** External view of SV. Note depressed sternum. **Fig. 30.** External view of RSV. **Fig. 31.** Internal view of RSV showing narrow, hyaline submarginal area delimited distally by marginal row of larger areolae.

***Cocconeis notata* Petit (Fig. 32)**

Petit 1877, p. 10, pl. 4, fig. 1; Hustedt 1933, p. 352, fig. 806; Poulin *et al.* 1984, p. 54, figs 22–25; De Stefano & Marino 2001, p. 297, figs 1–14, 44–46.

Valves broadly elliptical, 21 μm long, 13 μm wide. SV with narrow, sigmoid sternum and thin stauros-like area expanded into a small horseshoe-shaped area on only one side of valve. Striae uniseriate, 17–18 in 10 μm , parallel at the centre and curved radiate at apices. Areolae round, 16 in 10 μm .

Distribution: According to Hustedt (1933), *Cocconeis notata* is a cosmopolitan species. It has been previously recorded by Ferrario *et al.* (1982) and Ferrario & Ferreyra (1983) from the coastal waters of Santa Cruz (southern Patagonia, Argentina).

***Cocconeis pelta* A. Schmidt (Fig. 33)**

Schmidt 1874, p. 93, pl. 3, fig. 17; Hustedt 1933, p. 361, fig. 815.

Valves elliptical, 20–25 μm long, 14.5–16 μm wide. SV with linear sternum accompanied by a lanceolate central area, which is longitudinally limited by costae and covered with a loosely arranged, irregular ornamentation. Striae uniseriate, 14–18 in 10 μm , radiate throughout.

In our material we encountered some small elliptical specimens (15 μm long, 8 μm wide) with a higher striae density (22–24 in 10 μm) which resembled *Cocconeis pelta*. However, we have not included them in our analysis because the ranges for the morphometrics of both groups are discontinuous, and our observations made with LM did not allow us to evaluate if these small specimens are conspecific with this species.

In LM, *Cocconeis pelta* is morphologically close to *C. fluminensis* and *C. peltoides*. Similarities and differences among these taxa are discussed under *C. peltoides* (see below).

Distribution: *Cocconeis pelta* has been reported from European coasts in the North Atlantic (Cleve 1895, Van Heurck 1896, Peragallo & Peragallo 1897–1908, Hustedt 1933, Hendey 1964). It has been previously recorded in the Gulf of San Matías by Sar (1996b).

***Cocconeis peltoides* Hustedt (Figs 34–41)**

Hustedt 1939, p. 606, figs 23–27; Simonsen 1987, p. 253, pl. 376, figs 1–10; Sundbäck & Snoeijs 1991, p. 350, figs 9a–c.

Valves elliptical, 8–16 μm long, 5.5–10 μm wide. SV convex with a depressed, apically oriented, lanceolate area, externally limited by longitudinal costae, situated at varying distances from sternum. Longitudinal costae and interstriae thickened in the same manner. Striae uniseriate, 11–15 in 10 μm , parallel at the valve centre, curved radiate near apices. Areolae small, rounded, internally occluded, 25–50 in 10 μm , sometimes visible in LM. Mantle nearly vertical, separated from valve face by a conspicuous marginal ridge. Marginal row of small pores located at the striae end with internal openings surrounded by well silicified rims (Fig. 39, lower valve apex). Valvocopula open at one end, with peg-like fimbriae, all of the same length. RSV slightly concave, with a narrow, internally thickened sternum. Raphe branches straight, almost reaching valve ends. Externally, proximal and distal raphe endings coaxial. Internally, proximal raphe endings deflected in opposite directions, distal ones terminate in small helictoglossae. Striae uniseriate, 36–46 in 10 μm , parallel at the centre and radiate towards the apices, some striae not reaching the sternum. Areolae small, rounded, 40–45 in 10 μm . Elongated areolae in one row surrounding the valve margin (Fig. 41, upper valve apex).

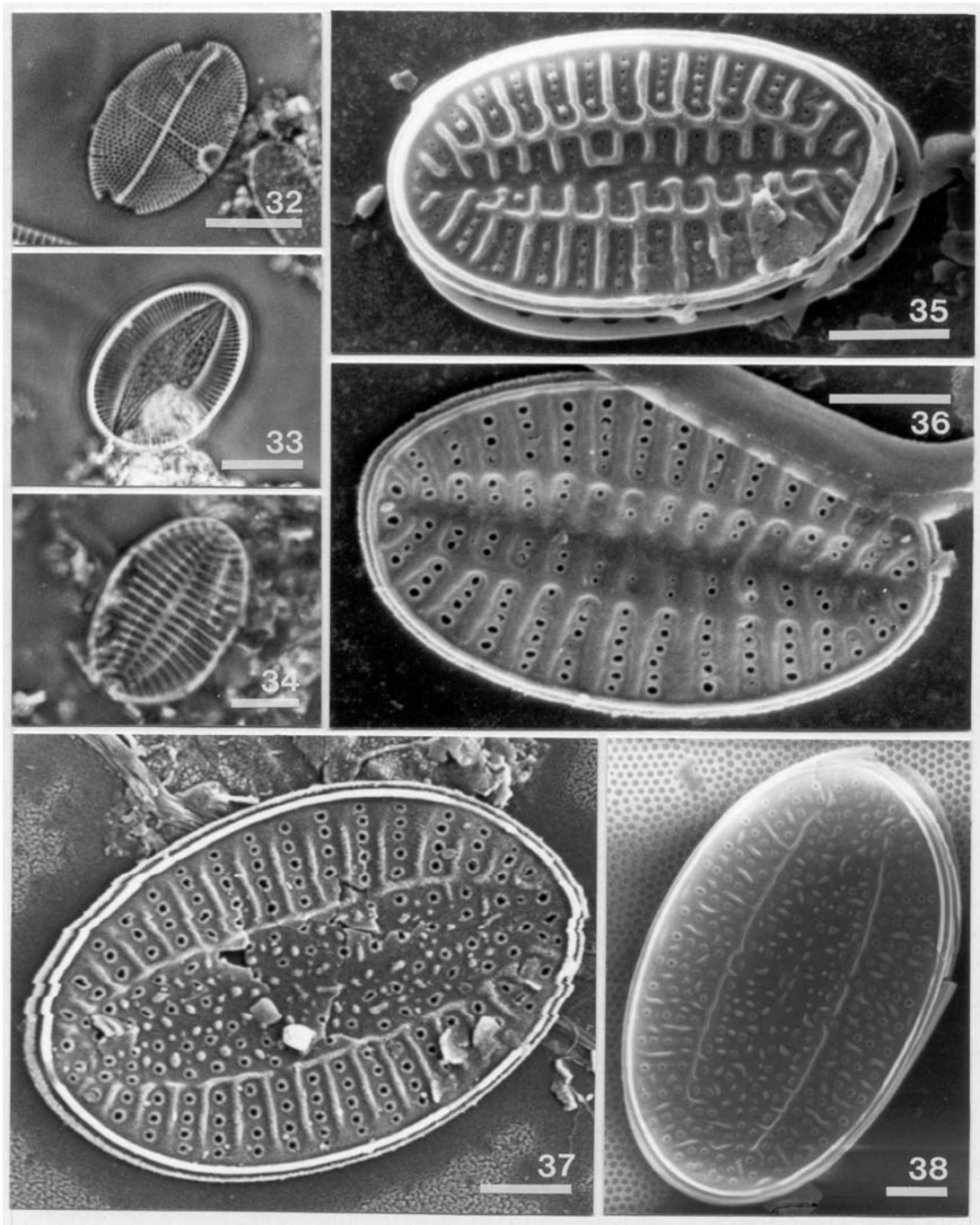
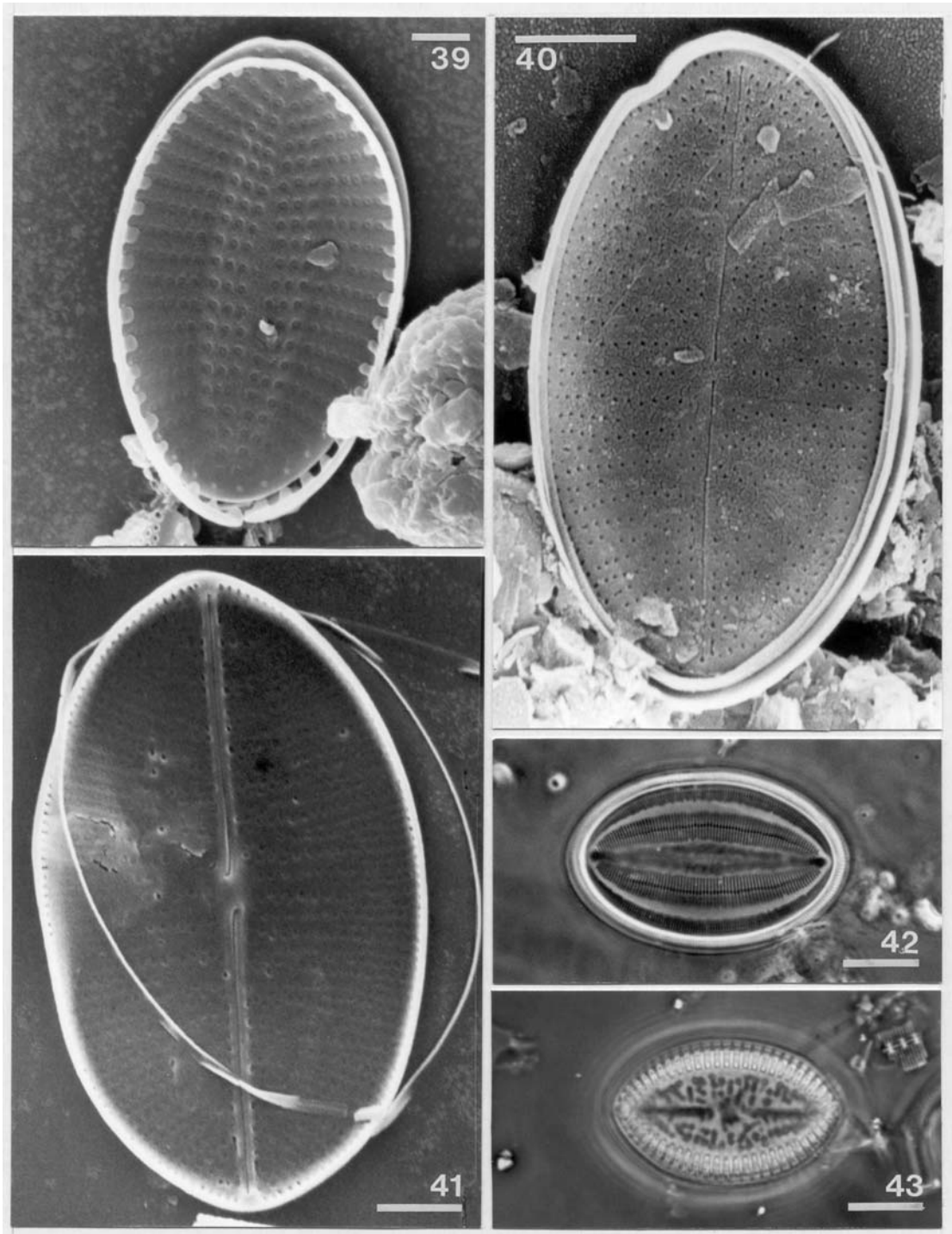


Fig. 32. *Cocconeis notata*, LM. SV showing sigmoid sternum, stauros-like area and small, horseshoe-shaped area. **Fig. 33.** *Cocconeis pelta*, LM. SV. **Figs 34–38.** *Cocconeis peltoides*. **Fig. 34.** LM. **Figs 35–38.** SEM. **Fig. 34.** SV. **Figs 35, 36.** External views of SV showing thickened longitudinal costae and interstriae. **Fig. 37.** External view of SV lacking thickening of interstriae in central region. **Fig. 38.** External view of SV with longitudinal costae and discontinuously thickened interstriae. Scale bars = 10 μm (Figs 32, 33), 5 μm (Fig. 34) or 2 μm (Figs 35–38).



Figs 39–41. *Cocconeis peltoides*, SEM. **Fig. 39.** Internal view of SV. Note open valvocopula with peg-like fimbriae. **Fig. 40.** External view of RSV. **Fig. 41.** Internal view of RSV. **Fig. 42.** *Cocconeis cf. pseudomarginata*, LM. SV. **Fig. 43.** *Cocconeis quarnerensis*, LM. SV. Scale bars = 10 μm (Figs 42, 43) or 2 μm (Figs 39–41).

We found some specimens that we consider part of *Cocconeis peltoidea*, although they have less strongly silicified longitudinal costae and interstriae (Figs 37, 38).

Cocconeis peltoidea resembles *C. fluminensis* and its var. *subimpleta* as well as *C. pelta* in its possession of a lanceolate area at the centre of the SV which is bordered by costae. In *C. peltoidea* (Figs 34–38) the striae reach the sternum, while in *C. pelta* (Fig. 33) they only reach the longitudinal costae. *Cocconeis fluminensis* (Fig. 14) and its var. *subimpleta* (Fig. 15) differ from *C. peltoidea* by their lower areolae density in the striae (14–17 versus 25–50 in 10 μm).

Distribution: Hustedt (1939) reported *Cocconeis peltoidea* from the North Sea, and Sundbäck & Snoeijjs (1991) found it in shallow coastal waters of the Baltic Sea. It is recorded here for the first time from marine coasts of the southwestern Atlantic Ocean.

***Cocconeis* cf. *pseudomarginata* Gregory (Fig. 42)**

Gregory 1857, p. 20, pl. 1, fig. 27; Romero & Navarro 1999, p. 582, figs 1–6, 13–15, 20–31.

Morphometric data: length 32–40 μm , width 19–25 μm , striae in 10 μm , SV 24.

In LM, our specimens (Fig. 42) closely resemble those from Southern Chile assigned by Romero & Navarro (1999, figs 3, 13–15, 20–31) to *Cocconeis pseudomarginata*. However, the South American specimens show a prominent external submarginal costa which is not present in specimens from type material illustrated by Romero & Navarro (1999). Based on our observations we consider that it would be necessary to study the type material of *C. pseudomarginata* with EM in order to confirm if this taxon is really conspecific with the South American one.

Distribution: According to Cleve (1895) and Hustedt (1933) *C. pseudomarginata* has a cosmopolitan distribution. This species has been reported once by Frenguelli (1938) from San Blas Bay (northern Patagonia), on the doubtful basis of a raphe-sternum valve.

***Cocconeis quarnerensis* (Grunow) A. Schmidt (Fig. 43)**

Schmidt 1874, p. 93, pl. 3, figs 15, 16; Hustedt 1933, p. 360, fig. 814; Witkowski *et al.* 2000, p. 123, pl. 55, figs 2–7.

Valves broadly elliptical-lanceolate, 28–31 μm long, 17–20 μm wide. SV flat to slightly convex with a broad lanceolate central region bearing irregular, loosely arranged ornamentations. Striae 6–7 in 10 μm , parallel at the valve centre, radiate towards apices.

Witkowski *et al.* (2000) transferred *Cocconeis quarnerensis* to the genus *Planothidium* Round & Bukhtiyarova (1996). This genus was defined on the basis of: (a) bi- to multiseriate striae, continuous in both valves in the *delicatula* type and centrally interrupted in the *lanceolate* type; (b) interstriae internally thickened; (c) RSV with a prominent raphe often centrally expanded and turned to the side at the valve apices. Witkowski *et al.* (2000) included *C. quarnerensis* in the *delicatula* group based on the following characteristics: (a) striae are multiseriate (composed of 5–6 rows of puncta), and continuous (even though not stated by authors); (b) interstriae are strongly silicified; (c) the raphe has somewhat expanded, external central endings and apical endings terminating in polar position. However, some *Cocconeis* taxa have bi- to multiseriate striae and interstriae that are internally thickened (e.g. *C. pseudocostata* Romero, *C. stauroneiformis*, *C. fasciolata* (Ehrenberg) N.E. Brown, see Romero 1996b; *C. pinnata* Gregory ex Greville, *C. costata* Gregory and its varieties, see Romero & Rivera 1996). Furthermore, some species have expanded central raphe endings (e.g. *C. costata* and varieties, *C. pinnata*, see Romero & Rivera 1996; *C. dirupta* var. *dirupta*, see Kobayasi & Nagumo 1985).

Terminal raphe fissures are absent in *Cocconeis* (see Round *et al.* 1990) while they are turned to the side in *Planothidium* (Round & Bukhtiyarova 1996). Based on these arguments and considering the illustrations of Witkowski *et al.* (2000), we disagree with their transfer of *Cocconeis quarnerensis* to the genus *Planothidium*.

Distribution: *Cocconeis quarnerensis* has been reported from Greenland by Boyer (1927), and from European coastal waters by Cleve (1895), Hustedt (1933), Cleve-Euler (1953), Hendeby (1964) and Witkowski *et al.* (2000). It has been recorded from the coastal waters in northern Patagonia by Frenguelli (1938, 1939a) and Sar (1996b).

***Cocconeis scutellum* Ehrenberg (Figs 44–50)**

Ehrenberg 1838, p. 194, pl. 14, fig. 8; Romero 1996b, p. 363, figs 2–17.

Morphometric data: length 17–33.6 μm , width 11–22 μm , striae in 10 μm , SV 6–9.5, RSV 8–12, areolae in 10 μm , SV 10–14, RSV 13–25.

Our observations coincide with those of Mizuno (1987) regarding the extreme variability in the valve morphology of *C. scutellum*.

Distribution: According to Hustedt (1933) and Hendeby (1964), *Cocconeis scutellum* is cosmopolitan. It has been reported from several locations in Argentinean coastal waters (see Ferrario & Galván 1989).

***Cocconeis stauroneiformis* (Rabenhorst) Okuno (Figs 51–57)**

Okuno 1957, p. 217, figs 2, 6/2; Romero 1996b, p. 373, figs 25–54.

Morphometric data: length 11–18 μm , width 6.6–10 μm , striae in 10 μm , SV 9–11, RSV 8–11, areolae in 10 μm , SV 14–18, RSV 16–24.

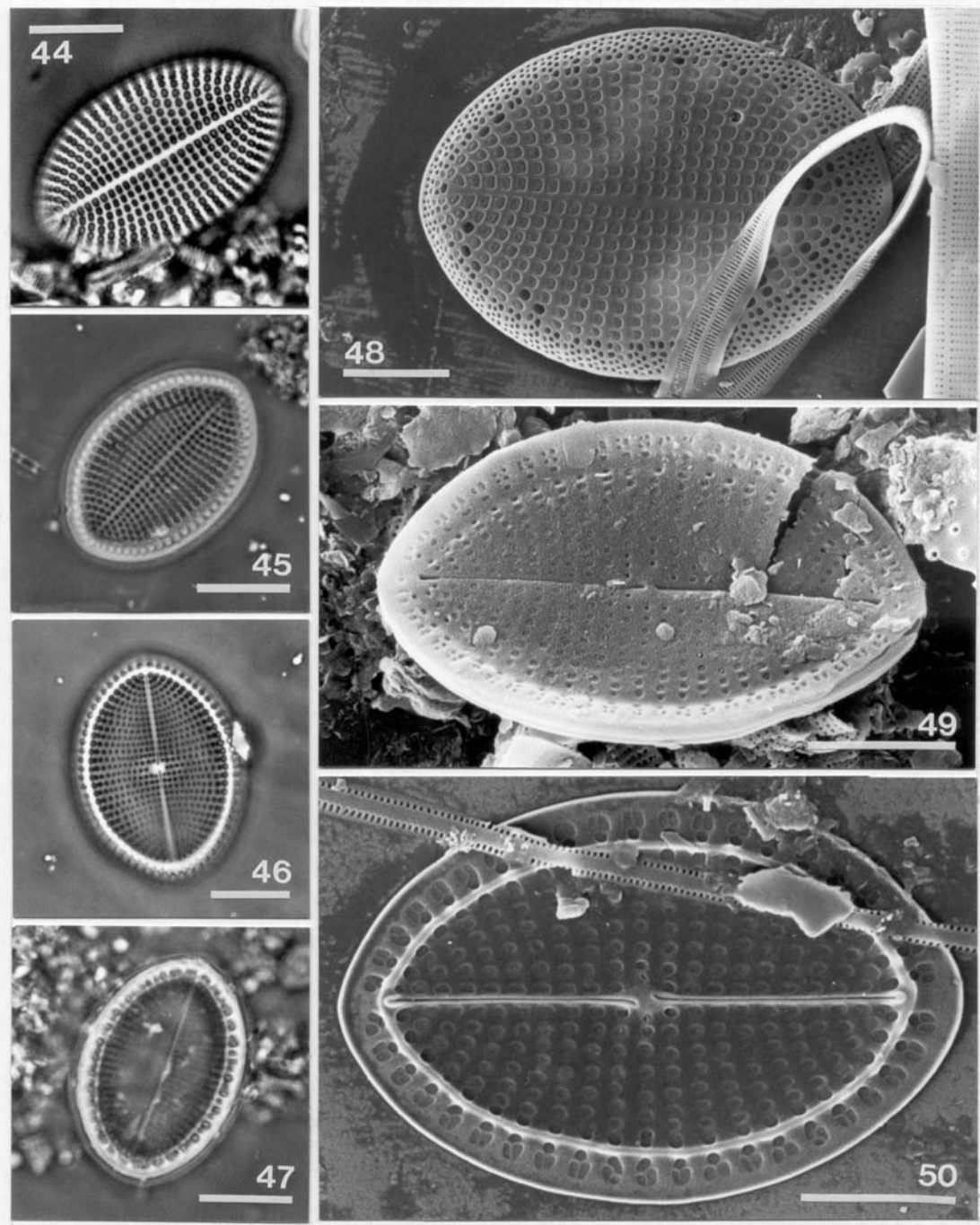
Cocconeis stauroneiformis appears similar in LM to *C. costata* Gregory, *C. pseudocostata* Romero and *C. fasciolata* (Ehrenberg) Brown. All these species share several common features of the RSV, such as a stauros and an internal, submarginal rim interrupting the striae. However, the suites of morphometric and ultrastructural characteristics justify their existence as separate taxa. For a comprehensive comparison of these four species see Romero (1996b) and Romero & Rivera (1996).

Distribution: *Cocconeis stauroneiformis* has a cosmopolitan distribution (Hustedt 1933, Hendeby 1964, Romero 1996b) and it has already been reported in Patagonia coastal waters by Ferrario *et al.* (1988) and Sar (1996b) as *C. scutellum* var. *stauroneiformis* Rabenhorst.

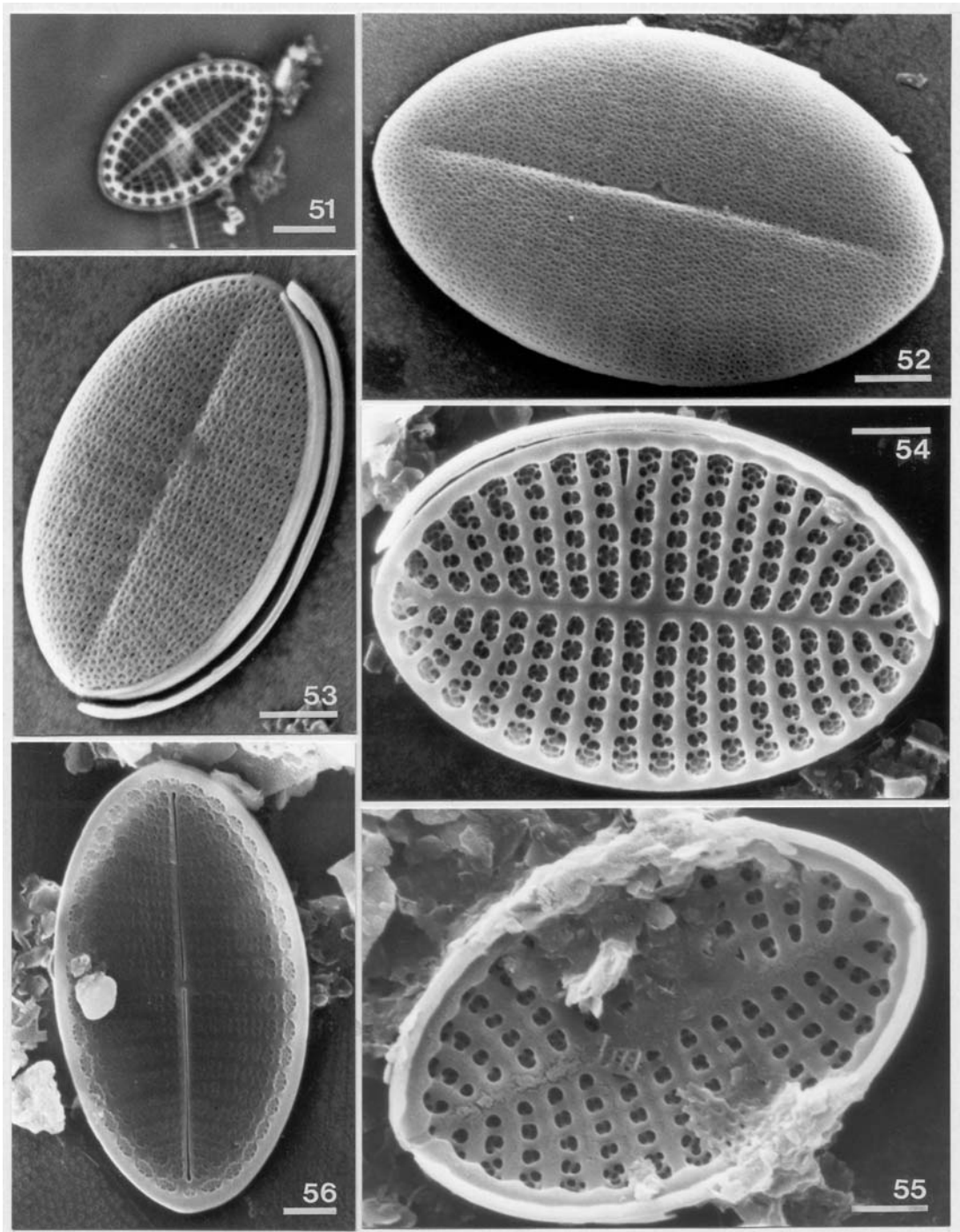
***Psammococconeis* cf. *disculoides* (Hustedt) Garcia (Figs 58–73)**

Hustedt 1955, p. 17, pl. 5, figs 8–11, pl. 7, fig. 8; Garcia 2001, p. 311, figs 12–25.

Valves elliptical to broadly lanceolate, 8.5–36 μm long, 4.3–23 μm wide. SV slightly convex with a narrow, linear to lanceolate sternum. Central area lacking. Striae coarse, uniseriate, gently radiate at valve centre, curved radiate towards apices, 7–16 (24) in 10 μm . Areolae large, subrectangular, sometimes circular, 5–14 in 10 μm , arranged in longitudinal rows. Areolae externally recessed and internally occluded by hymenes. Valvocopula open with broadly laminate fimbriae, all of the same length. RSV slightly concave. Raphe branches straight, bordered by a linear, narrow sternum. Central area small and rounded. Proximal raphe endings coaxial and slightly expanded externally. Terminal raphe endings externally curved in the same direction. Striae uniseriate, straight and radiate at centre, strongly radiate and curved towards apices, 16–19 in 10 μm . Two continuous rows of areolae visible in



Figs 44–50. *Cocconeis scutellum*. Figs 44–47. LM. Figs 48–50. SEM. Scale bars = 10 μm (Figs 44–47) or 5 μm (Figs 48–50). **Figs 44, 45.** SV. Note valvocopula with its regularly arranged peg-like fimbriae. **Figs 46, 47.** RSV. Note valvocopula with its two distinct types of fimbriae. **Fig. 48.** External view of SV. **Fig. 49.** External view of RSV. **Fig. 50.** Internal view of RSV.



Figs 51–56. *Cocconeis stauroneiformis*. Fig. 51. LM. Figs 52–56. SEM. Scale bars = 5 μm (Fig. 51) or 2 μm (Figs 52–56). **Fig. 51.** RSV. **Figs 52, 53.** External views of SV. Note continuous volate hymenes covering outer valve surface and depressed sternum. Interstriae may or may not be visible. **Figs 54, 55.** Internal views of SV. Note valvocopula with crenulate margins, opened at one end. **Fig. 56.** External view of RSV.

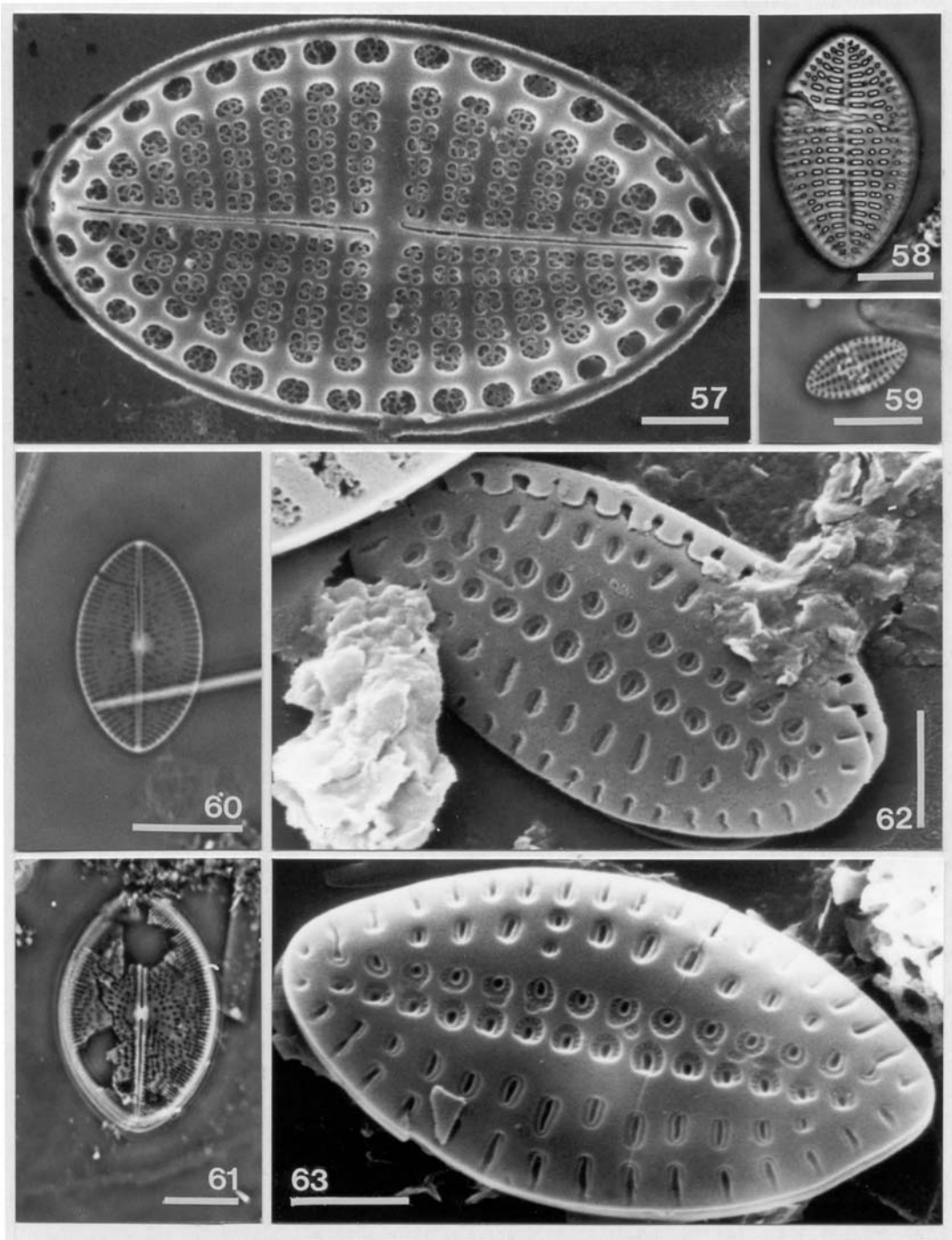
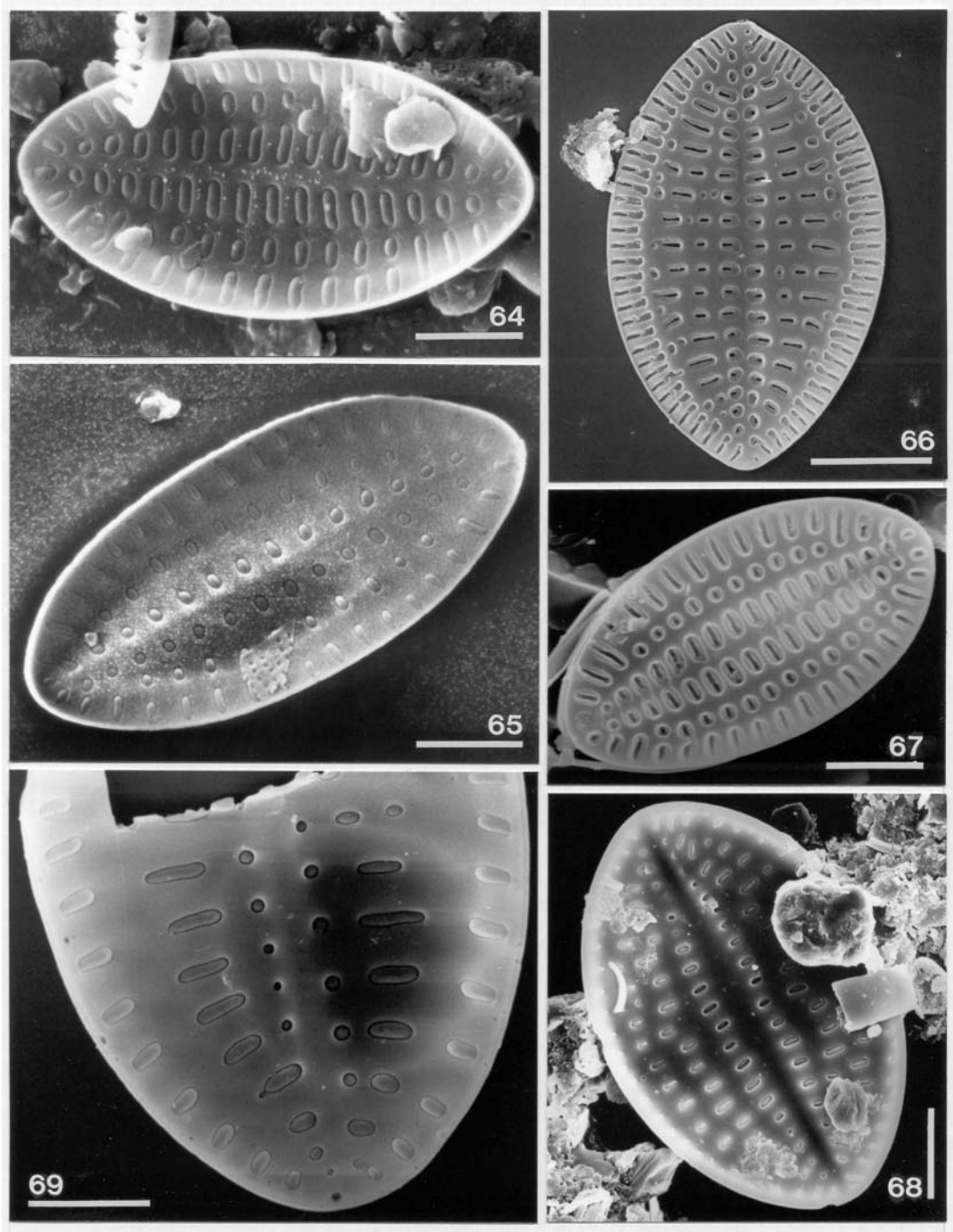


Fig. 57. *Cocconeis stauroneiformis*, SEM. Internal view of RSV. **Figs 58–63.** *Psammococconeis* cf. *discoloides*, Gulf of San Matías. Figs 58–61. LM. Figs 62, 63. SEM. **Figs 58, 59.** SV with different general appearance. **Figs 60, 61.** RSV. **Figs 62, 63.** External views of SV. Note valvocopula with broad, lamina-like fimbriae. Scale bars = 10 μ m (Figs 58–61) or 2 μ m (Figs 57, 62, 63).



Figs 64–69. *Psammococconeis cf. disculoides*, SEM. Scale bars = 5 µm (Figs 66, 68) or 2 µm (Figs 64, 65, 67, 69). **Figs 64, 65.** Gulf of San Matías. Internal views of SV. Note different areola morphology. **Figs 66–69.** Type material, sample AM 792 corresponding to Zt1/92, Hustedt Collection. **Figs 66, 67.** External views of SV. Note differences in arrangement of areolae. **Figs 68, 69.** Internal views of SV. Note occlusion of areolae by hymenes.

LM on each half valve: one marginal row of elongated areolae and one composed of shorter areolae arranged parallel to the raphe sternum. Shorter rectangular to rounded areolae, loosely arranged, cover rest of the valve surface. Areolae internally occluded by hymenes. Valvocopula sheet-like, extending beneath entire valve surface, ornamented by elongated to round poroids (Fig. 71).

We have examined in LM type material of *Cocconeis disculoides*: slides Zt1/79 and Zt1/92 designated as the lectotype and isolectotype, respectively by Simonsen (1987). Moreover, we have also studied with SEM sample AM 792 corresponding to material used by Hustedt for preparation of the type slides (Figs 66–69, 72, 73). In our examination of this material, we found some valves which fit the protologue in Hustedt (1955), and other smaller valves (up to 8.4 μm long and 4 μm wide) which have much higher striae and areolae densities in the SV (up to 18 striae and 11 areolae in 10 μm). Hustedt (1955) pointed out that in smaller specimens the structure of the SV is often very delicate. In our material we found large specimens with low striae and areolae densities, small specimens with high striae and areolae densities, and others intermediate between these groups. All such specimens and those in the type material share the same basic morphology; thus, we conclude that they all belong to the same species. We therefore propose to enlarge the range in morphometric data given in the protologue as follows: length 8.5–36 μm , width 4–23 μm , striae in 10 μm , SV 7–24, RSV 16–24.

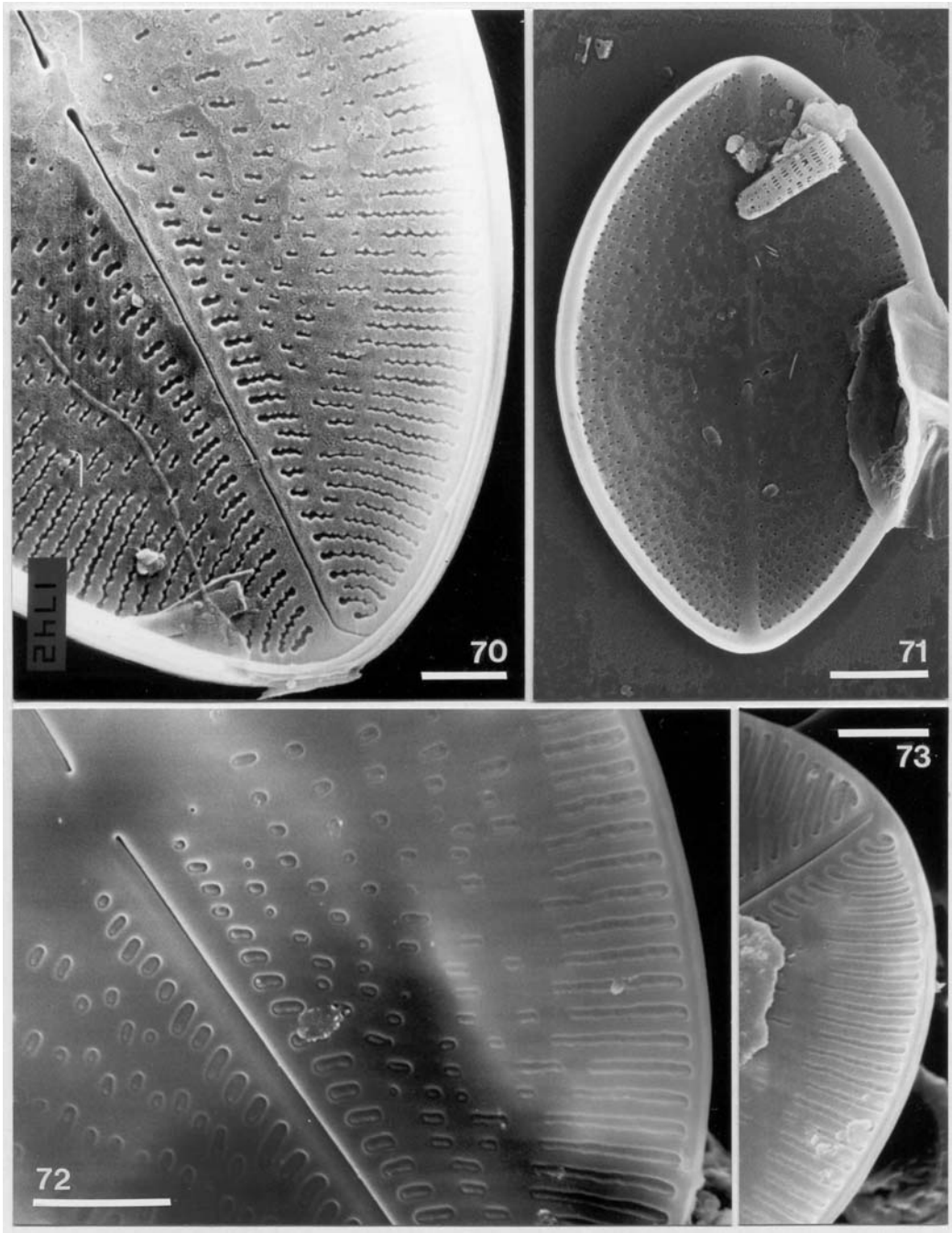
Garcia (2001) recently transferred *Cocconeis disculoides* Hustedt to her newly erected genus *Psammococconeis*, based mainly on the occurrence of two types of areolae close to the margin of the SV, characteristics of the raphe endings (simple and not expanded) and morphology of the RSV valvocopula. Our material and Hustedt's possess, in contrast to Garcia's, a marginal row of areolae in the SV (Figs 62–68) composed of one type of areola internally occluded by hymenes. Moreover, central raphe endings are externally expanded and terminal raphe endings are curved in Argentinian material (Fig. 70). This last feature was also observed in Hustedt's material by M. De Stefano (personal communication) who, based on this and other features, suggests transferring this species to a new genus. Considering that our species is the same as Hustedt's, that both differ from Garcia's species, and that the comments of De Stefano are based on a thorough study of type material, we have decided to designate our taxon as *Psammococconeis cf. disculoides*.

Distribution: *Psammococconeis cf. disculoides* has been reported from several localities: marine littoral of North Carolina (Hustedt 1955), Chesapeake Bay (Cooper 1995), Gulf of California (Moreno *et al.* 1996), east coast of Florida (Navarro 1982b), British North Sea coastal waters (Hendey 1964) and Argentinian coast (Sar 1996b) as *Cocconeis disculoides*.

DISCUSSION

Cocconeis and *Psammococconeis* are benthic diatom genera that are characterized by heterovalvate frustules. Since we based our survey on plankton samples, it was difficult to find sufficient specimens of some taxa in order to relate both valves of the same frustule, hence in some cases only the SV or RSV is illustrated. In spite of this, we were able to record *Psammococconeis cf. disculoides* and 16 species and varieties of *Cocconeis* in the Gulf of San Matias. The occurrence of *Cocconeis* taxa in the phytoplankton of this area is explained by the strong resuspension of bottom material caused by the tidal currents in the shallow waters of the San Antonio Bay and neighbouring coastal environments.

Our specimens of *Psammococconeis cf. disculoides* show greater variability than that described in the species' protologue (Hustedt 1955). On analysing the type material we found a similar variability as that observed for specimens collected in the Gulf of San Matias; hence, we conclude that the ranges in morphometric features of this species should be expanded. Furthermore, the valve outline, broadly elliptical to lanceolate in our populations, is similar to that observed in the type material, despite the fact that it was originally described as elliptical. The external morphology of the areolae of the SV, which are recessed in the basal siliceous layer and open by slits, has been observed in all the valves



Figs 70–73. *Psammococconeis* cf. *discoloides*. SEM. Scale bars = 5 μm (Fig. 71) or 2 μm (Figs 70, 72, 73). Figs 70, 71. Gulf of San Matías. **Fig. 70.** Detail of RSV in external view. Note expanded central raphe endings and curved terminal fissure. **Fig. 71.** Valvocopula of RSV. Figs 72, 73. Type material, sample AM 792, corresponding to Zt1/92, Hustedt Collection. RSV in internal view. **Fig. 72.** Detail of areolae occluded by hymenes. **Fig. 73.** Detail of terminal raphe ending.

studied by us, though their shape is variable even within the same valve. In contrast to Garcia (2001), who recently transferred *Cocconeis disculoides* to her newly erected genus *Psammococconeis*, we found in *P. cf. disculoides* a marginal row of areolae all similar to each other, areolae in both valves internally occluded by hymenes, proximal raphe endings externally expanded and curved terminal fissures. Therefore, in agreement with M. De Stefano (personal communication), we believe that it is necessary to critically reevaluate the transfer of *C. disculoides* to the genus *Psammococconeis* by Garcia (2001).

Cocconeis peltooides exhibits considerable variability in the morphology of its longitudinal costae and interstriae. They are thickened and continuous in more heavily silicified specimens, while in others either the interstriae are not thickened in the central part of the valve or the longitudinal costae and interstriae are discontinuously thickened. These differing morphologies may be a result of temporal changes in ecological conditions in the study area or they may simply be part of the morphological variability characterising the population.

We elucidated the valve morphology of *Cocconeis guttata*, where the external structure of the SV possesses depressed interstriae, raised striae and areolae surrounded by small siliceous granules. As far as we know such a pattern is only known in this species among *Cocconeis* taxa.

Our materials containing the unidentified *Cocconeis* sp. (Figs 9–12) indicate both valves possess a similar striae density as that given in the description for *Cocconeis diminuta* (Pantocsek 1902). In several works (e.g. Hustedt 1933), small forms of *Cocconeis* with valves having dissimilar stria densities have been erroneously attributed to *C. diminuta*. Such observations have contributed to the confusion surrounding the identity of this taxon. Based on Krammer's (1990) study we consider the name *C. diminuta* to be a *nomen dubium*, which can not be applied to our taxon. This entity needs more analysis before being erected as a new species.

Our results have generated questions concerning the validity of one taxon and the correct identification of a second taxon. We propose that the type material of *Cocconeis diruptoides* should be compared with that of *C. dirupta* var. *flexella* in order to determine whether they are independent taxonomic entities. In the case of *C. pseudomarginata*, it is necessary to study its type material to determine if Romero & Navarro (1999) have correctly attributed their specimens to this taxon.

The SV of a population we have tentatively identified as *Cocconeis cf. costata* var. *pacifica* possesses a morphology very similar to *C. costata* var. *pacifica* including its axial plate. However, it has much higher striae and areolae densities than the other varieties of *C. costata*. We plan to analyse more specimens of this diatom in order to elucidate the morphology of its RSV and the full range of variability of the SV before considering the erection of a new variety.

We have extended the geographical distribution of some *Cocconeis* taxa. The recently described *C. neothumensis* var. *marina*, and *C. fluminensis*, *C. fluminensis* var. *subimpleta*, *C. guttata* and *C. peltooides* are new records for Argentina and the southwestern Atlantic Ocean.

This work represents a preliminary study of the distribution and morphology of *Cocconeis* and *Psammococconeis* taxa as a component of the tychoplanktonic diatom flora of Argentinean coastal waters. In order to more completely monograph the *Cocconeis* flora of the study area it will be essential to focus our collection efforts on epiphytic and epilithic habitats where this genus may be especially abundant.

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